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SEVERING ADHESIONS IN ARTIFICIAL PNEUMOTHORAX BY THE ELECTROSURGICAL METHOD[1]

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PROCEDURES for establishing functional rest of the lung and closure of cavities through lung collapse, or compression, represent a very distinct advance in the treatment of pulmonary tuberculosis. Of the various methods of collapse therapy, artificial pneumothorax is the most valuable, most widely applicable and most extensively employed. It is deplorable that its application is restricted to less than half the cases wherein it is indicated because of pleuritic adhesions allowing either no collapse of the lung at all, or insufficient collapse to provide adequate rest or closure of cavities. An ineffective pneumothorax, caused by pleuritic adhesions, is a common experience to all who employ artificial pneumothorax in the treatment of pulmonary tuberculosis; and the greatest indictment against the method, no doubt, is the persistence with which an ineffective pneumothorax is continued month in and month out (sometimes for years), when clinical and roentgenological evidence clearly shows an unsatisfactorily collapsed lung still a source of tubercle bacilli-laden sputum, fairly constant in its quantity because of an open cavity. In such cases, sooner or later, the disease extends to the opposite lung, intestines or larynx. The case is often then too far advanced for other surgical collapse measures, and the patient is destined to chronic invalidism, facing a certain doom.

According to our experience in over 1,500 cases of pulmonary tuberculosis treated by artificial pneumothorax, 40 per cent of failures in pneumothorax therapy have been caused by pleuritic adhesions which prevented a satisfactory collapse of the lung.

As a result of our observations, we are convinced of the importance of establishing a type of pneumothorax which, within 4 to 6 months, will give the diseased lung sufficient functional rest, collapse, or compression to render it no longer a source of tubercle bacilli-laden sputum, or tuberculotoxæmia.

Stretching adhesions in an effort to secure a satisfactory lung collapse by gradually increasing the intrathoracic pressure, is seldom successful (except when minor adhesions are present) and may precipitate a tear, resulting in spontaneous pneumothorax and empyema. Opening the pleural cavity to cut adhesions is tolerated poorly by tuberculous patients, and the results do not justify the procedure.

If severing adhesions by surgical methods comes into question, undoubtedly the much neglected method of closed intrapleural pneumolysis is the procedure of choice. In selecting the closed method of approach, we have for consideration the method proposed by Jacobaeus in 1913, utilizing the galvanocautery for cutting purposes, or, instead of the galvanocautery, the electrosurgical method, utilizing a high-frequency current, may be used according to the author's technique (7, 8).

The cauterization of adhesions by the galvanocautery is objectionable because of the heat, smoke, pain, and reaction following operation. Perhaps its greatest shortcoming is the character of the cutting produced, as tissue is destroyed a short distance around the cautery; thus, blood vessels are severed without any previous obliteration, unless a dull red heat is used (dark-room control), and undue bleeding may occur. In addition to the danger of bleeding, if too much heat is employed, there is also the possibility of tissue necrosis occurring, which may involve the parenchyma of the lung, tuberculous cavities or tuberculous foci, resulting in spontaneous pneumothorax and empyema.

Because of the obvious objections to the galvanocautery and the success of electrosurgery, especially in brain and cancer surgery, it seemed very probable that this method could be applied intrathoracically with advantage. Several years ago, we began studies of this method, which necessitated the development of technique and instru-

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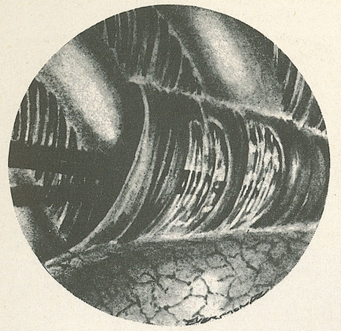

Fig. 1. Arachnoid adhesion showing electrode passed through its meshes. It never contains lung tissue nor blood vessels.

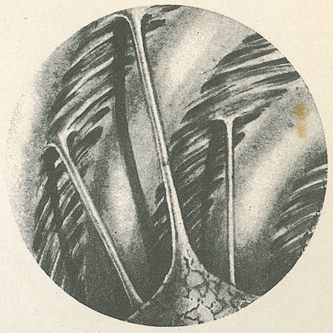

Fig. 2. Three string adhesions of various sizes extending between the partially collapsed lung and chest wall. This type never contains lung tissue nor blood vessels.

ments which now, after 4 years' application, are sufficiently perfected and tested to offer as superior to galvanocautery instruments and method.

In adapting the electrosurgical method of closed intrapleural pneumolysis, the disadvantages of the galvanocautery have been eliminated, and many definite advantages achieved by the use of this more modern and adaptable cutting method.

The indications, contra-indications, and selection of cases for operation have been fully discussed in the author's previous communications.

PLEURITIC ADHESIONS

Before discussing the operative technique, a brief description of adhesions commonly met with at operation will be given; but no attempt will be made in this compilation to discuss their origin.

A. *Arachnoid adhesions* (Fig. 1). These, when recent, separate readily without cutting. They never contain lung tissue and are not of technical importance.

B. *String adhesions* (Fig 2). These are usually round, but sometimes flat; some are elastic and fragile while others are vascular. As a rule, only a slight increase is seen in their diameter at the chest wall and lung attachments. They are of little clinical importance except when numerous and fibrous.

C. *Cord adhesions* (Fig. 3). This form has the same characteristics as the former group, only they are larger, and while essentially round, at times show ridging. The thoracic wall and lung attachments are often slightly broadened, especially when short, and might be then mistaken for spool or capstan adhesions. They are seldom highly vascular but are of technical importance, as a satisfactory collapse of the lung is often prevented by a single cord adhesion.

D. *Band adhesions* (Fig. 4). These vary greatly in their length, thickness, and breadth. They rarely contain lung tissue but sometimes blood channels of considerable importance are encountered. This type is of great technical importance. Aside from bleeding, severance, which should be made close to the chest wall, is not associated with danger.

E. *Fan-shaped adhesions* (Fig. 5). In this form, small blood vessels are often contained in the free edge. The transition between lung tissue and adhesion is clearly defined. They rarely contain lung tissue and should be severed near the lung attachment. Cutting is not dangerous and a good therapeutic result follows.

F. *Funnel or cone-shaped adhesions* (Fig. 6). This type commonly occurs over superficial cavities, in which case the cavity is often projected into the adhesion. Cutting them, unless around the chest wall attachment, is dangerous.

G. *Spool or capstan adhesions* (Fig. 7). These contain blood channels of marked importance,—also prolongations of cavities. The pulmonary half always contains lung tissue. Although they are less dangerous to cut than the funnel type, they often present the same hazards and should be severed near the chest wall.

H. *Fold and curtain adhesions* (Fig. 8). While frequently appearing as bands on stereoscopic films, giving the impression of being easily cut, they are mostly non-operable, except when thin.

I. *Diffuse adhesions* (Fig. 9). In this type, the lung is densely adherent to the chest wall. They are responsible for more failures in pneumothorax

Fig. 3. Cord adhesions. The somewhat triangular and round type of cord adhesions are shown. Neither contain lung tissue nor blood vessels, but should be severed close to the chest wall instead of in the middle.

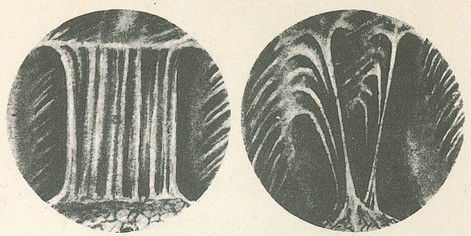

Fig. 4. Two types of band adhesions. They may contain blood vessels but rarely lung tissue, and should be cut at the chest wall attachment.

than any other kinds of adhesions, and are seldom suitable for cutting.

THE ELECTROSURGICAL METHOD (AUTHOR'S METHOD)

A detailed description of the physical characteristics of electrical currents employed in electrosurgery will not be given here, as the subject has been well covered by Ward, Clark, and Cushing. However, for the purpose of cutting pleuritic adhesions by the closed method, when hæmostasis by the usual surgical procedure is denied, a brief description of the intrathoracic application is justified.

The cutting effected by the electrosurgical method is not a true cutting, but a molecular disintegration of tissue produced by a high frequency, undamped current—an arc being formed at the point of contact between the tip of the electrode and the tissue. By this method, blood and lymph vessels are sealed, no bleeding occurs and danger of liberating infection from the cut adhesion is infinitely less. There is no radiating heat, no smoke to disturb the view, less pain, and only a very mild reaction after operation.

Intrathoracically, 3 types of current are used to accomplish, first, superficial dehydration; second, coagulation; and third, cutting.

Superficial dehydration is seldom used, as the cutting current delivered by the Bovie Unit[1] has sufficient dehydrating properties to prevent bleeding in severing adhesions containing small blood-vessels (up to 2 or 3 mm.)

[1]Manufactured by the Liebel-Flarsheim Company, Cincinnati, Ohio. For the past three years, we have used the Bovie Unit exclusively and found it ideal.

Coagulation is widely employed as a preliminary preparation to the cutting of all adhesions containing, or suspected of containing blood vessels of a moderate size. Coagulation of vascular tissue is the best preparation for cutting, which may be done immediately after coagulation, or, at times, better left to future operations if large blood vessels are seen. Often safe spontaneous separation or stretching may take place, obviating the necessity of a later cutting operation. In an old pneumothorax with a thickened pleura, it is frequently difficult to come to a conclusion regarding the nature of the tissue to be cut. Our procedure in this type of case is to surround the chest wall attachment of the adhesion with a path of electrocoagulation (Fig. 10). After the chest wall has been sealed (24 to 48 hours), reinflations are energetically pursued, and in a short time the coagulated area usually separates, or the adhesion will be seen to stretch out into a slender cord (Figs. 11 and 12).

Cutting. The form best adapted for intrathoracic purposes is a current of extreme high frequency with a wave form known as moderately damped. While the degree of dehydration depends to some extent on the cutting surface of the operating electrode (which is quite blunt) and the amount of power, depth, and speed at which the instrument is moved, it depends chiefly on the character of the current or wave form—this may be varied to suit the type of tissue being severed. The greater the blood supply, the greater the degree of dehydration or coagulation that must be used.

PRE-OPERATIVE PREPARATION OF THE PATIENT

The patient is prepared as for a major thoracic operation. Serous exudate, except when present only in very small quantities, ought to be aspirated a few days before operation, and a pneumothorax refill given at this time (if necessary) to provide as large as possible a pneumothorax in which to

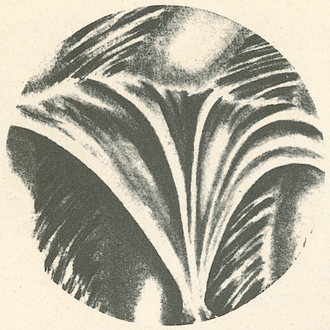

Fig. 5. View of a fan shaped adhesion with base attached to the ribs and intercostal muscles, and rounded apex attached to the lung. Lung tissue is rarely present but may contain blood vessels of considerable size. Should be cut adjacent to the lung attachment.

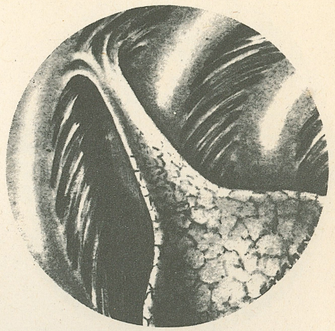

Fig. 6. Funnel or cone shaped adhesion. This type contains lung tissue and often the prolongations of a cavity and blood vessels; should be cut at the chest wall attachment, if operable. Otherwise, this type of adhesion may be electrocoagulated.

work. If the pleural cavity contains a purulent exudate, it should be washed out with salt solution before operation. In the event of a febrile reaction occurring following aspiration, it is best to postpone the operation until no such reaction follows. If the patient is apprehensive, a mild sedative may be given the night before operation to insure a good sleep, and sputum drainage should be carried out in the morning before operation, so as to prevent excessive coughing during and immediately after operation. Immediately before operation, an injection of pantopon or morphine is usually advisable.

THORACOSCOPY

Undoubtedly, the most valuable method of determining the possibility of severing adhesions is by thoracoscopic examination of the pneumothorax cavity. The possibility of operation and the degree of success or failure can be determined, in many cases, only by this method: therefore, it should be utilized in any doubtful case, as it is harmless.

The instruments (Fig. 13) required for thoracoscopy are, preferably, an Unverricht thoracoscope[1] with transformer to control its illumination, and a trocar and bakelite cannula[2], by means of which the thoracoscope is introduced through the thoracic wall. After working with numerous thoracoscopes, both direct and indirect, as well as operating thoracoscopes, we believe the Unverricht thoracoscope is the best for general use.

[1]Manufactured by Carl Zeiss, 485 Fifth Ave., New York, N. Y.
[2]Manufactured by Carl McKissick, 425 S. E. 6th Ave., Portland, Oregon.

Author's trocar and cannula. The trocar is adjustable to the different lengths of the cannulas. Three different lengths of cannulas are available for use, according to the thickness of the chest wall. The cannulas, of a size to fit the thoracoscope, are made of bakelite, preventing short circuiting of the high frequency current to the chest wall when used with the operating electrodes.

The position of the patient on the table depends upon the operative approach. In most instances, the pneumothorax side will be up (Fig. 14), as most adhesions will be found in the posterior upper quadrant of the pneumothorax cavity. However, the point of entrance of the thoracoscope will depend entirely upon careful study of the stereoscopic films.

We prefer the posterior approach, not only because most adhesions can be more accurately and conveniently studied from here, but also because the intercostal vessels, at this point, lie in the rib sulcus, and are well protected from injury during introduction of the trocar and cannula for the thoracoscope. The anterior approach for the thoracoscope is never used by us except in the case of apical adhesions anteriorly located.

Local anæsthesia for the introduction of the thoracoscope is similar to that for a pneumothorax refill. Caution must be exercised in approaching the pleura, lest the lung be close to the chest wall and punctured. Careful infiltration of the endothoracic fascia is essential. The intercostal space being used is injected with 10 cubic centimeters of 1 per cent novocain suprarenin solution, but there is no need to anæsthetize the intercostal spaces above and below the site of puncture.

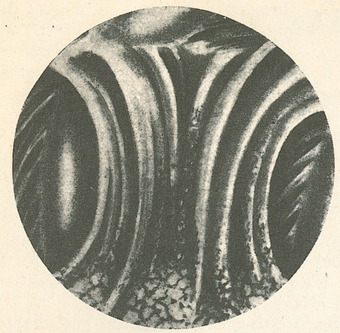

Fig. 7. Spool shaped adhesion containing compressed lung tissue and blood vessels. This type of adhesion should not be cut at its narrowest part but at its chest wall attachment, if at all. This type is ideal for electrocoagulation.

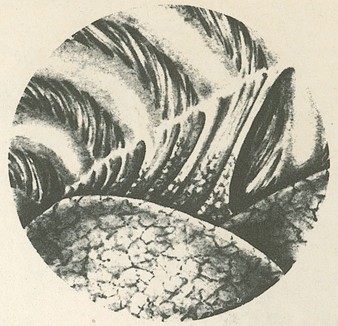

Fig. 8. Fold or curtain adhesion. Arises from an interlobar pleuritis. May contain lung tissue and blood vessels. Should be severed (if at all) at the chest wall by transillumination.

It is necessary to make sure that the lung, by chance, is not adherent to the chest wall, or that an adhesion not shown on the roentgen film, is not attached at the point of entrance selected for the thoracoscope. Also, it is important to know whether the lung, if not adherent, is far enough away from the chest wall, or, if an adhesion is present, that it is sufficiently distant to permit manipulation of the thoracoscope. These difficulties are simplified by a preliminary sounding of the pneumothorax cavity with a Solomon catheter through a small cannula introduced through a puncture at the site selected for the thoracoscope (Fig. 15). Next, a 1 centimeter incision is made through the skin, and the trocar and bakelite cannula[1] for the thoracoscope are gently pushed through the chest wall in a horizontal direction. The outer end is depressed and the tip of the instrument directed upward, thus avoiding the trickling of blood down the shaft of the cannula, which might later foul the lens. Care must be taken to avoid suddenly plunging the trocar through a thickened pleura that offers considerable resistance.

The room is then darkened, the trocar withdrawn from the cannula, and the thoracoscope introduced in a horizontal direction, with the lens up. A general survey of the pneumothorax cavity is made, followed by a careful study of the adhesions which should furnish complete orientation regarding their position and direction with relation to the chest wall and collapsed lung, as well as their dimensions, configuration and type. It is particularly essential to know how close the point selected for cutting is to large blood vessels or important nerve trunks. The presence of lung tissue, blood vessels, and tuberculous deposits in the adhesions to be cut should be determined; following this, a study is made of the inner chest wall, and a site selected for entrance of the operating electrode—one that will give an unobstructed view and permit placing the cutting instrument in the most advantageous position across all important adhesions at a proper angle for the purpose of cutting, and avoid introducing the electrode at a point where adhesions prevent its being seen, as, for instance, on the blind side of adhesions.

[1]The author uses a bakelite cannula for the thoracoscope instead of the Unverricht ball-valve type because it permits an interchange of instruments; moreover, the ball-valve cannula is unnecessary as the intrathoracic pressure is equalized the moment the cannula for the operating instrument is introduced.

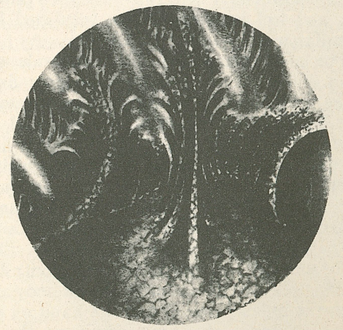

Fig. 9. Diffuse adhesion. The parietal and visceral pleura are intimately fused; lung tissue extends to the chest wall; blood vessels are abundant. Complete severance should not be attempted.

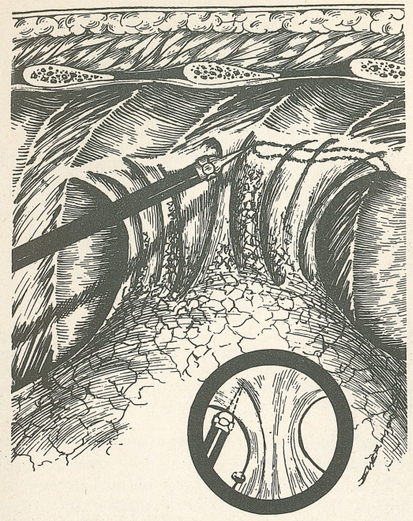

Fig. 10. Deep puncture coagulation of the chest wall attachment of a spool adhesion, showing electrode and line of coagulation. Insert, Pointed operating tip penetrating the chest wall attachment for deep coagulation.

ELECTROSURGICAL CUTTING

The instruments required for the electrosurgical method of cutting adhesions, aside from the electrosurgical unit, are: the operating electrodes, extensions and operating tips for the electrodes (Figs. 16 and 17). These instruments and their manipulation have been fully described previously (8), and full instructions are furnished by the manufacturer.

The point of entrance of the electrode will depend entirely upon the thoracoscopic findings. Since, in the majority of cases, the thoracoscope will be most advantageously introduced at the angle of the scapula, the anterior axillary line will prove a very suitable place for introducing the electrode—the intercostal spaces being wide and permitting a greater degree of manipulation of the instrument; furthermore, the relative position of the two instruments is very satisfactory. The area to be entered on the chest wall is controlled by making gentle pressure upon the intercostal space with the index finger of the free hand on the external surface—one then observes the result through the thoracoscope: if accurately located, the operator will observe, unless the pleura is very thick, a circumscribed bulging of the intercostal space as downward pressure is exerted by the finger (Fig. 18).

After suitable infiltration of the site determined upon for introduction of the electrode, the infiltrating needle is passed into the pneumothorax cavity and observed through the thoracoscope. The needle is then withdrawn sufficiently to allow careful infiltration of the pleura and endothoracic fascia. This area may be observed through the thoracoscope as a blanched one. Through a small skin incision, the trocar and cannula for the operating electrode are introduced in the same manner as that of the thoracoscope. Here, however, the maneuver is controlled by the thoracoscope.

After inserting the cannula for the thoracoscope, as described, the electrode is introduced and placed upon the adhesion. Decision as to the point where the adhesion is best cut will depend upon its type and its relationship to important structures.

In proceeding to sever the adhesion, one should bear in mind that the closer the cutting is to the chest wall, the greater will be the pain and danger of bleeding, inasmuch as sensation comes from the intercostal nerves, and the blood supply of adhesions is derived, mostly collateral, from the intercostal vessels. On the other hand, division near the lung, while painless, is dangerous, because one may open into a prolongation of a cavity projected within the adhesion or into compressed lung tissue and, in either event, precipitate a spontaneous pneumothorax or liberate infection—almost certain to result in empyema.

The beginner will do well to confine himself to string, cord, and small band adhesions; the spool, funnel, and curtain types should be avoided. It must be a fixed rule never to cut any tissue until the operator is perfectly familiar with its structure.

TABLE I*.—COMPLICATIONS AFTER OPERATION INCLUDING THE GALVANOCAUTERY AND AUTHOR'S METHOD—249 CASES

	No.	Per Cent
Serous exudate	63	25.7
Purulent exudate	41	16.5
Hæmorrhagic exudate	26	10.4
Febrile reaction	7	2.4
Severe hæmorrhage	3	1.2
Bronchopleural fistula	4	1.6
Spontaneous pneumothorax	1	.4
Severe postoperative vomiting	1	.4
Gas embolism	0	
Shock	0	
Severe surgical emphysema	0	

*This table comprises complications occurring in 136 patients operated upon with the galvanocautery and 113 operated upon by the author's method. However, in 35 of the latter group, an obsolete high frequency apparatus was used, while in 78 cases the Bovie unit was employed.

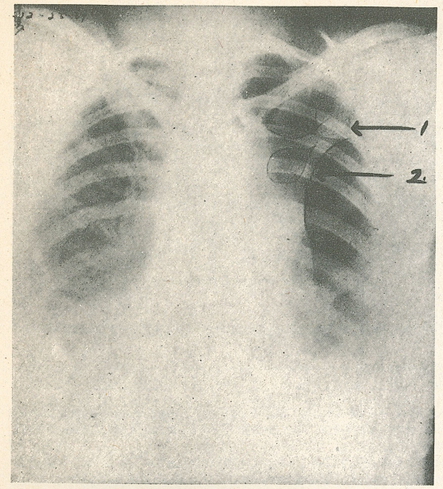

Fig. 11 (retouched). Cone shaped adhesion preventing collapse of a cavity, *2*, which is prolonged into the adhesion. *1*, Shows the chest wall attachment after electrocoagulation. The configuration and size of this cavity had remained unaltered by a pneumothorax in the previous 3 months.

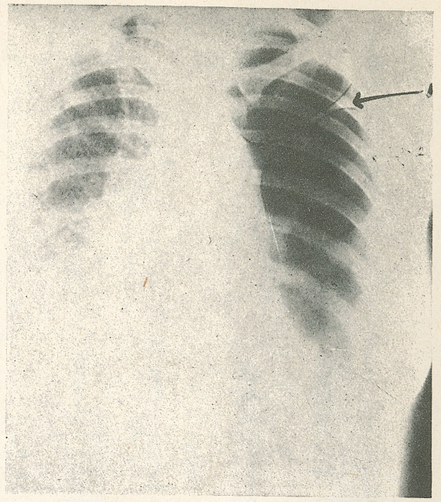

Fig. 12 (retouched). The same case 1 month later. The cavity is completely closed.

After the adhesion has been completely cut through, a careful examination is made for bleeding, which must be arrested by application of the coagulation current. If bleeding has taken place, the pleural cavity should be washed clean with salt solution.

The operator, having satisfied himself that everything is in order within the pneumothorax cavity, the instruments are withdrawn and the incision closed with a single gut suture.

The patient is emphatically warned against coughing. A small roll of one-inch gauze bandage for compression is held firmly over the site of the puncture and this is covered with strips of three-inch adhesive plaster, extending well to the front and back.

TABLE II.—COMPARATIVE FREQUENCY OF EXUDATE FORMATION FOLLOWING VARIOUS OPERATIVE METHODS—249 CASES

	Jacobaeus method		Author's method			
	Galvanocautery, 136 cases		Unnamed high frequency unit 35 cases		Bovie high frequency unit 78 cases	
	No.	Per cent	No.	Per cent	No.	Per cent
Serous exudate	28	20.5	11	31.4	3	3.8
Purulent exudate	36	26.4	4	11.4	2	2.5
Hæmorrhagic exudate	14	10.3	11	31.4	1	1.2

POSTOPERATIVE CARE

The postoperative care consists in absolute bed rest, with the side operated upon up for the first 24 hours. Cough should be controlled during the first 24 to 48 hours with codeine, dionine, or even morphine, if necessary. Bed rest is maintained for a minimum of 7 days. Straining at stool and physical efforts, including excessive laughter, are prohibited.

The strictness and duration of the postoperative care, before the case reverts to the medical service for continuance of pneumothorax treatment depends upon the character of the operation and the patient's reaction. As a rule, the postoperative course, following electrosurgical cutting, is mild: at times, a temperature of 99 to 100 degrees F. may last but a few days. Postoperative pain, if any, is slight and easily controlled with codeine.

After 24 to 48 hours, a roentgen film should be made, and the time and quantity of gas reinflation decided upon. The intrapleural pressure usually will be less than before operation. Positive pressures must be avoided, when possible; but, should thick walled cavities be present with thickened pleura, it may be necessary to resort to positive

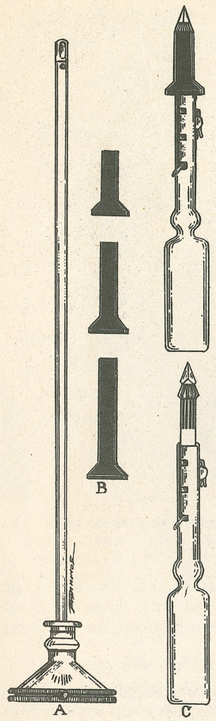

Fig. 13. *A*, Unverricht thoracoscope. *B*, Three lengths of bakelite cannulas. *C*, Author's adjustable trocar.

Fig. 13.

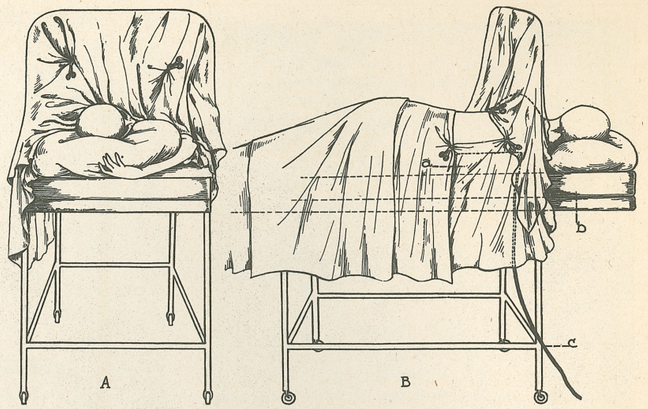

Fig. 14. Position of patient on operating table for an intrapleural pneumolysis on the left side. *A*, Anterior view, showing the manner of draping the sterile sheets; the position of the head and arms of the patient is also shown. *B*, A sheet of diathermy metal, *a*, is placed beneath the patient and connected with the electrosurgical unit by a cable, *c*. The patient rests upon a cellular rubber pad, *b*.

pressures to secure closure of offending cavities. If cavity drainage is interfered with, and sputum retained, it may be necessary to aspirate air and slightly expand the lung to establish drainage, following which, frequent refills with smaller quantities of sterile air should be carried out until a satisfactory collapse is established and the patient rendered sputum-free. Reinflation is carefully controlled by the X-rays, and, for the first few inflations, a roentgenogram should be made, if possible, after every air injection.

Barring complications, the sanatorium patient may be back on the pre-operative routine in 1 to 2 weeks. Ambulant and working patients, admitted for operation, are individualized regarding their routine.

COMPLICATIONS

The complications after operation, in our entire series of 249 cases, are shown in Table I. But it should be pointed out that the first 136 cases were done with the galvanocautery, and of the remaining 113 cases, 35 were performed with an unnamed high frequency machine which provided a cutting current, yet possessed no dehydration qualities; whereas, the last 78 cases were operated upon with the Bovie unit. Table II shows the marked reduction in exudate formation incidence following use of the Bovie unit. It should be mentioned that of the three instances of severe hæmorrhage, one occurred during use of the galvanocautery and 2 during operation with the unnamed high frequency machine. The single instance of spontaneous pneumothorax occurred on the contralateral side 7 days after operation; it was due to an asthmatic paroxysm and was fatal. This case represents the only fatality in the entire series, directly or indirectly due to operation.

RESULTS OF TREATMENT

During the past 7 years, 311 operations have been performed on 249 cases (Table III). In 211 cases, a single operation was done, in 22 cases, 2; and 10 cases had 3 operations; 4 cases had 4 operations, and 2 cases had 5 operations each.

In estimating the value of the operation, it must be borne in mind that the purpose of the operation is to convert a useless, or unsatisfactory, pneumothorax into an efficient one. Accordingly, the results of operation have to do, primarily, with the number of unsatisfactory pneumothorax cases which were converted into satisfactory ones, and

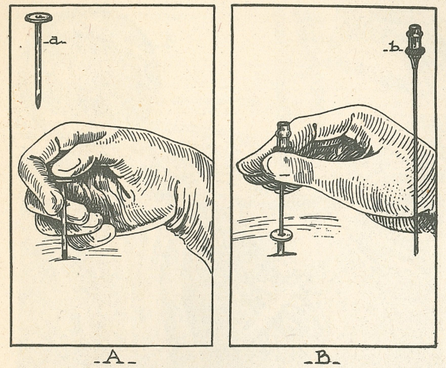

Fig. 15. Method of palpating for the lung and nearby adhesions to determine whether site is suitable for introduction of the thoracoscope. *A*, Introducing the cannula, *a*. *B*, Introducing the Solomon blunt needle, *b*.

remotely to the end-result of the pneumothorax thus established. Every case classified as "clinically and technically successful" from the standpoint of the operation, means that complete severance of all adhesions was effected, followed by a satisfactory pneumothorax with prompt (sometimes immediate) disappearance of severe cough and expectoration.

Of the 249 cases, 152, 61 per cent, were technically and clinically successful. Of these, 32 cases had to deal only with string and cord adhesions. In 85 cases, band adhesions alone were present; in 18 cases only fold adhesions, and in 4 cases, all three types of adhesions were present.

The technically unsuccessful but clinically successful group comprises 19 cases presenting all the above types of adhesions, as well as others described under the classification of "adhesions." This group embodied cases wherein some adhesions, because of their character, were left uncut, yet sufficient collapse of the lung was obtained to bring about a satisfactory clinical result by electrocoagulation.

It has been pointed out that clinical success is not always dependent upon cutting all adhesions. A determination as to the ones of technical importance should be made and only these severed. Those unimportant technically, if of an unfavorable type for operation, should not be molested. Of the 249 cases forming a basis of this study, 172, 70 per cent, obtained a clinically successful result.

The technically successful but clinically unsuccessful cases were two; one of these, previously quoted, died of a spontaneous pneumothorax 7 days after operation, and the other of sudden profuse hæmorrhage from the successfully collapsed lung (24 hours after operation), which, due to her position, with the pneumothorax side up, filled the dependent sound lung. This patient had profuse bleeding from an open cavity before operation; the operation was planned to effect closure of the cavity. The technically and clinically unsuccessful group comprises 76 cases; 40 of these presented only fold adhesions and 34 had fold adhesions in combination with others of the string, cord or band type. These latter were severed; but the remaining fold adhesions prevented a satisfactory collapse of the lung.

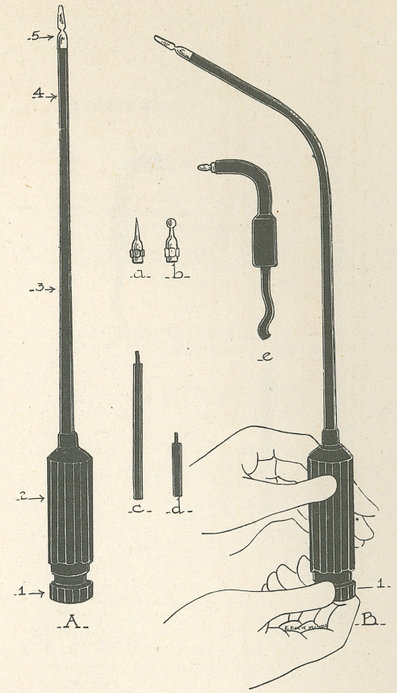

Fig. 16. Author's flexible electrode. *A*, The instrument straight. *1*, Fluted disk for flexing instrument. *2*, Hand grip. *3*, Hard rubber shaft, except distal one-fourth which has a soft rubber covering. *4*, Medium shaft extension. *5*, Operating tip. *B*, The instrument flexed by turning disk, *1*. *a*, Pointed tip for cutting and deep coagulation. *b*, Coagulating tip. *c*, Long shaft extension. *d*, Short shaft extension. *e*, Connection with unit which fits in the shaft of the hand grip.

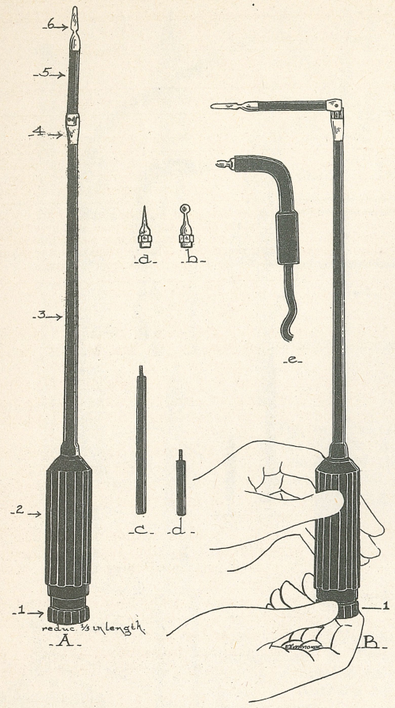

Fig. 17. Author's jointed electrode. *A*, The instrument straight. *1*, Disk for angulating the instrument. *2*, Hand grip. *3*, Hard rubber shaft. *4*, Metal joint. *5*, Medium extension. *6*, Operating tip. *B*, The instrument angulated by turning the disk, *1*. *a*, *b*, *c*, *d*, and *e*, the same as in Figure 16.

The remote results, in the cases operated upon, are shown in Table III. Of the 152 technically and clinically successful ones, 120 were bed cases and 32 were ambulant before operation; 146 cases had a positive sputum; in 6, it was negative. All these latter 6 were patients who had been under satisfactory pneumothorax, but the adhesions were contracting and causing an early lung expansion. These cases had been under observation for 5 years, during which time pneumothorax treatment was continued for at least 2 years. Eight more recent ones are still bed cases; 18 are ambulant, and 126 are working—all have a negative sputum. Of the 19 technically unsuccessful but clinically successful ones, all were bed cases, and all had tubercle bacilli in their sputum. Four

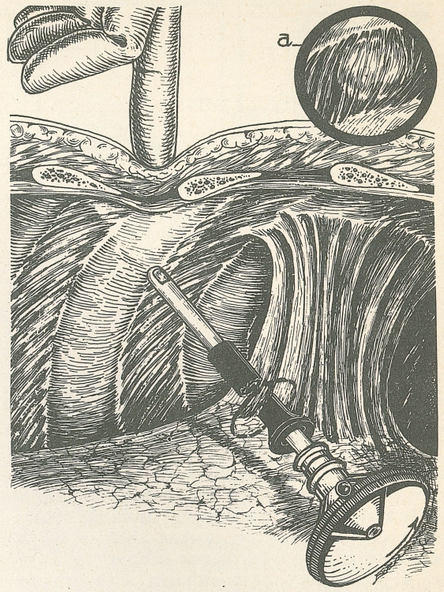

Fig. 18. Method of selecting the site for introducing the operating electrode through the chest wall. *a*, Thoracoscopic view showing elevation produced by pressure of the finger.

years after operation, 7 are ambulant and 12 are working. All have a negative sputum.

CONCLUSIONS

It is unjustifiable to continue an unsatisfactory pneumothorax over a prolonged period, because of the danger of extensions of the disease to the opposite lung, to the gastro-intestinal tract or to the larynx. Our experience covering the past 20 years, and including over 1,500 cases of artificial pneumothorax, has demonstrated that intrapleural pneumolysis under thoracoscopic guidance will convert approximately 70 per cent of unsatisfactory cases of pneumothorax into satisfactory ones. We have shown that less than 15 per cent of recoveries take place as the result of the continuation of an unsatisfactory pneumothorax, and that serious dangers attend the use of high intrapleural pressures in an attempt to stretch adhesions. If the adhesions prevent a satisfactory collapse of the lung, after a probation of 4 to 6 months, it is very improbable that a satisfactory end-result will be obtained by further continuation of the pneumothorax. After a trial has been given, an unsatisfactory pneumothorax should be converted into a satisfactory one by intrapleural pneumolysis. If this is impractical, other surgical collapse methods should be utilized.

TABLE III.—INTRAPLEURAL PNEUMOLYSIS REMOTE END-RESULTS OF OPERATION—249 CASES

Result of operation	Cases	Condition before operation: Bed	Amb.	Sputum Pos.	Sputum Neg.	Present condition: Bed	Amb.	Wk.*	Sputum Pos.	Sputum Neg.	Remarks
Technically and clinically successful	152	120	32	146	6	8	18	126		152	Working 83 per cent
Technically unsuccessful, clinically successful	19	19		19			7	12		19	Working 68 per cent
Technically successful, clinically unsuccessful	2	2		2							Two dead: 1 from spontaneous pneumothorax after operation: 1 from hæmorrhage opposite lung.
Technically and clinically unsuccessful	76	62	14	76							This group comprised cases presenting adhesions unsuited for operation. In most cases minor adhesions of no technical importance were severed. In all appropriate cases patients were subjected to other operative collapse procedures. The end-result is not attributable to the pneumolysis—consequently not recorded here.

*Wk.—Working.

The electrosurgical method is superior to the galvanocautery and the operation is not dangerous when properly performed. Our mortality was 1.5 per cent in 249 cases, including the use of both the galvanocautery and the electrosurgical method. This single operative mortality was only indirectly due to the operation.

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